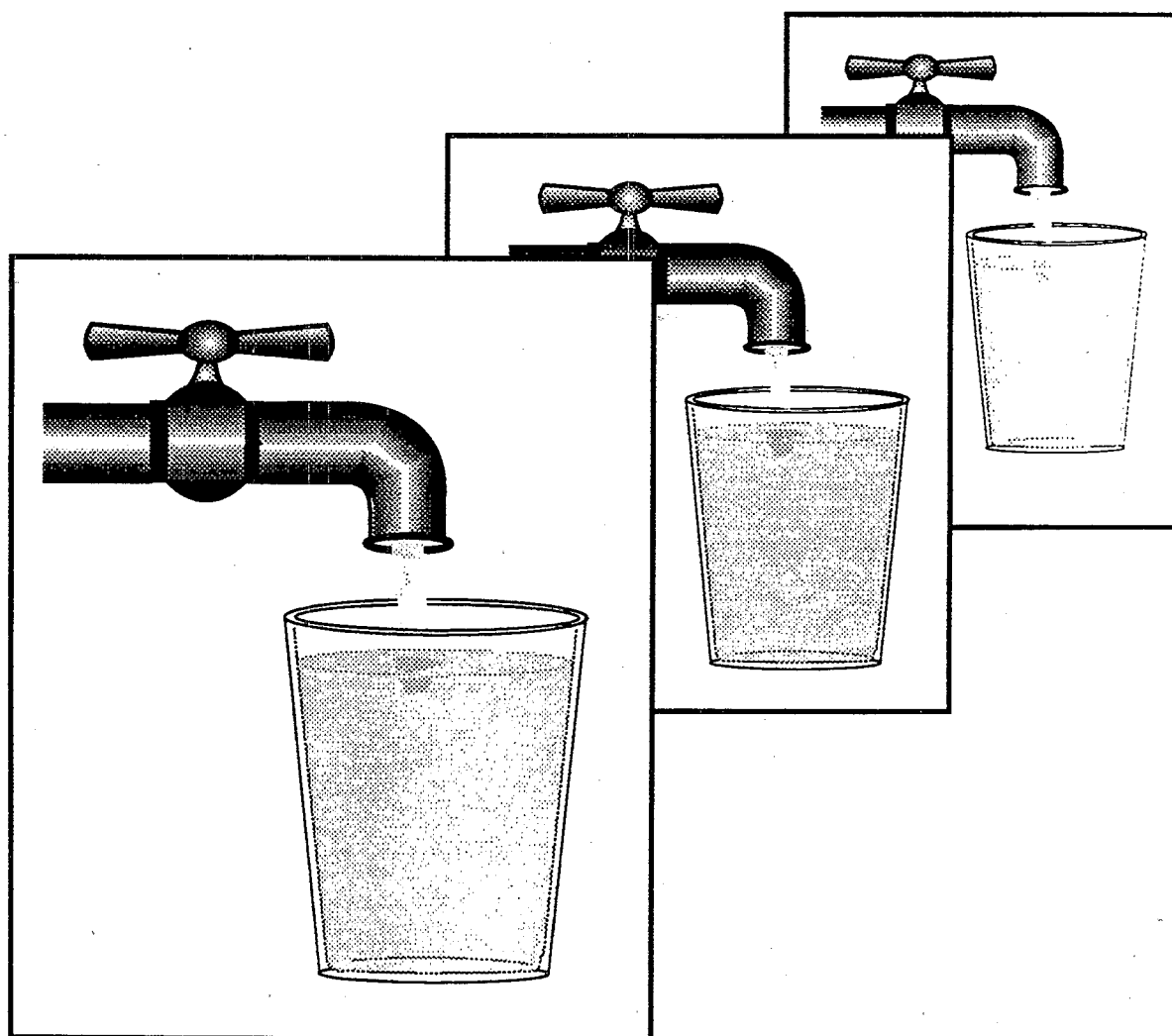




Science Demonstration Projects in Drinking Water (Grades K-12)



introduction

This pamphlet includes a brief selection of science demonstration projects related to drinking water for K-12 students. The projects are organized according to the following grade categories: primary (K-4); middle/junior high (5-8); and secondary (9-12). The divisions between grade categories are arbitrary. The projects are essentially applicable to all grade levels. By simply varying the vocabulary and expanding or contracting the background and discussion sections, each project can be made relevant to a specific grade level.

The general areas covered by the demonstration projects include the chemical/physical aspects of water, contamination and treatment of drinking water, distribution and supply of drinking water, and water conservation. While the projects presented are complete activities, teachers are encouraged to expand the projects to meet the needs and goals of their respective teaching situations.

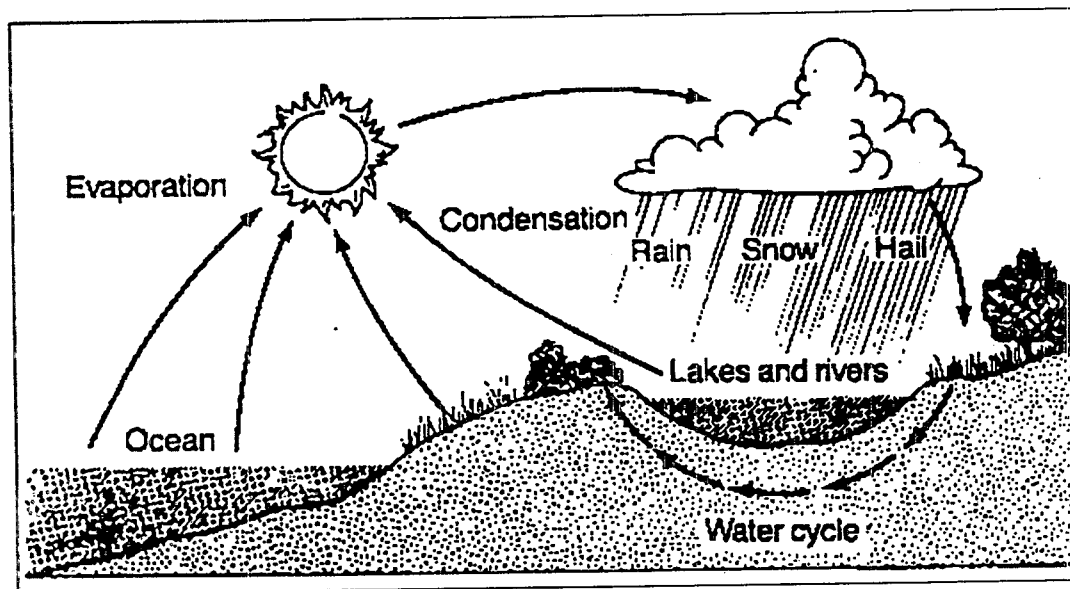
The demonstration projects included in this pamphlet are representative of many such projects developed by talented professionals in the science, engineering, and education communities. The projects have been reprinted in whole or in part with the permission of the appropriate publishers. Reference and/or credit information is included with each activity. In addition, a list of organizations that have developed or are developing projects related to drinking water are included at the back of this document.

primary

The Never Ending Cycle of Water

Background

Water is very abundant on Earth. It circulates continuously between the air, the ground, and plants and animals. This constant circulation of water is known as the *water cycle*. Water is carried through air where it eventually **condenses** into small droplets which form clouds. From the clouds, water falls to the Earth in the form of rain or snow (**precipitation**). This water is absorbed into the ground or runs over the surface of the ground into rivers and lakes. Plants and animals use the water to live. Water then **evaporates** from soil, the leaves of plants, the lungs and skin of animals, and from the surface of puddles, streams, and lakes to the air.



Source: *Science Activities for Children*

Woodland plants (e.g., violets, ferns, or mosses—gathered in backyards or available from nurseries)

Water

Light source or a sunny window sill

Tight-fitting jar lid (or plastic wrap secured by rubber band or masking tape)

Procedure

- 1) Place a one-inch layer of gravel on the bottom of the clear glass jar. Cover this layer with one of sphagnum or peat moss, followed by a layer of soil (see illustration at right).
- 2) Set woodland plant(s) into the soil mixture.
- 3) Water terrain lightly.
- 4) Cover glass jar tightly with lid (if available) or with plastic wrap secured by a rubber band or masking tape and place under or near a light source.
- 5) Observe the glass jar over several hours.

Discussion

- 1) What collected on the sides of the glass jar? (condensed moisture)
- 2) Where did the moisture on the sides of the glass jar come from? (evaporated water from plants)
- 3) What provided the energy for the changes observed in the water's form? (the sun)

Objective

To demonstrate that water moves in a continuous cycle.

Materials

Large, wide-mouthed clear glass jar

Gravel*

Sphagnum or peat moss*

Soil*

*(available from hardware stores or nurseries)

Suggested Activities

Prior to conducting this activity, the teacher may wish to more fully demonstrate the processes of precipitation, evaporation, and condensation. In addition, a discussion or demonstration of water in its three states (solid, liquid, gas) might also be useful. Samples of such experiments can be found in the source material noted below.

Sources

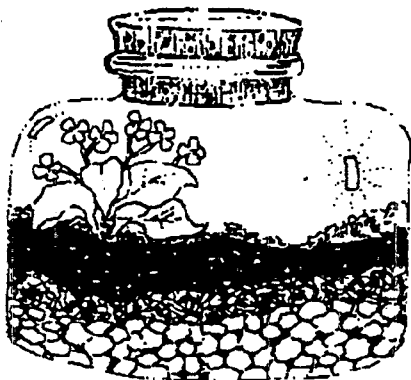
Background information adapted with permission from:

Willard J. Jacobson and Abby B. Bergman. *Science Activities for Children*. (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1983). p. 47.

Activity adapted with permission from:

Water Wizards. (Boston, MA: Massachusetts Water Resources Authority. 1983). pp. 2-4.

"Water: We Can't Live Without It." *National Wildlife Week Educators' Guide*. (Washington, DC: National Wildlife Federation, March 18-24, 1984). p. 7.



Source: *National Wildlife Week Educators' Guide*

How People Get Their Water

Background

Nearly 80 percent of the Earth's surface is water, yet less than one percent can be used for drinking water. Water moves in a continuous cycle between the air, the ground, and plants and animals (see previous activity). Most water does not naturally exist in a pure form or in a form that is safe for people to drink. Consequently, water must be cleaned prior to consumption. Water utilities provide such treatment before water is sent through pipes to homes in the community.

The demand for water by people varies. The availability of water also varies in different areas of the country. Consequently, utilities store extra water in spaces known as **reservoirs**. Water is usually contained in reservoirs by a dam. Reservoirs help ensure that communities do not run out of water at any given time regardless of the communities' total water use.

Activity #1

Objective

To illustrate how a reservoir works.

Materials

Plastic box

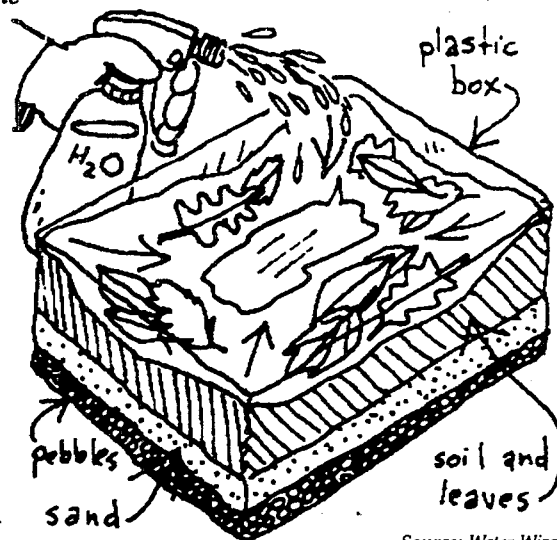
Spray bottle

Pebbles

Soil

Sand

Leaves



Source: *Water Wizards*

Procedure

- 1) Construct a model of a reservoir using a clean, clear plastic box (see illustration). Line the bottom of the box with small pebbles and then layer sand, soil, and leaves on top (sloping the material downward toward the edges of the box).
- 2) Carefully spray water on the four corners of the model until the soil mixture is saturated and the water has seeped through to the open area—the reservoir.

Discussion

- 1) What are the sources of water for a reservoir? (precipitation in the form of rain and snow)
- 2) How does water get into a reservoir? (It seeps over and through the soil above the reservoir.)
- 3) What contains or holds water in a real reservoir? (dams)
- 4) What kind of treatment does water receive in a reservoir? (natural filtration through leaves, grass, and soil; also some settling occurs in the reservoir)

primary

Activity #2

Objective

To build a model of a water delivery system from source to user.

Materials

Large piece of paper or cardboard

Paper towel tubes

Different sizes of pasta (linguini, spaghetti, manicotti)

Glue

Reservoir built in Activity #1 (optional)

Procedure

- 1) Using the pasta and paper towel tubes, create a community pipe system (see illustration). Connect the "pipes" with glue and lay out on the large sheet of paper or cardboard.
- 2) Either use the reservoir constructed in the previous activity or draw one on the cardboard; also draw houses, schools, and other buildings that receive water from the delivery system.

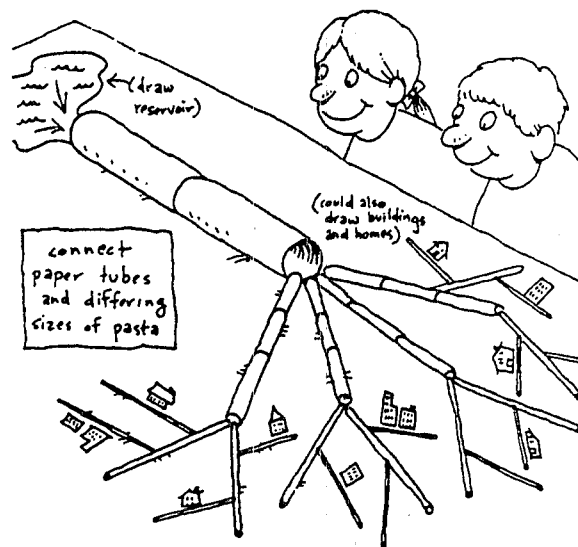
Discussion

Students should consider how water gets from reservoirs to distribution systems and to individual homes. (The circumference of pipes decreases as the distribution system expands into the community. As water travels through a distribution system, it is continuously diverted down different pathways. These pathways lead to individual homes and businesses. The circumference of a pipe determines the quantity of water that can be contained in the pipe at any one time and determines, in part, the rate at which the water will travel through the pipe. As the distribution system expands to homes and businesses, the volume of water needed per home or business represents only a portion of the total volume leaving the treatment plant. Consequently, smaller pipes are needed in these areas of the distribution system, whereas larger pipes are needed near the treatment plant. Water treatment plants generally pump water from the reservoir to holding or water towers. The water flows by gravitational force from the water tower and throughout the distribution system.)

Source

Activities adapted with permission from:

Water Wizards. (Boston, MA: Massachusetts Water Resources Authority, 1983). pp. 10-14.



Source: Water Wizards

Conserving Water for The Future

Background

Water is very valuable to us. We all need approximately 2 liters of water each day. We can live several weeks without food, but can only live several days without water. Water makes up our body's blood (which is 83% water), transports bodily wastes, and helps us digest our food. We get most of our body's daily requirement of water from food. But water is a limited resource, which means that there is only so much water on Earth available for use. In order for water to be available when needed, it must be conserved.

Objective

To emphasize the need for water conservation.

Materials

One 12 ounce clear glass

Water

Question and answer sheet for each student

Procedure

- 1) Explain to the students that they are conducting an experiment that will test what it is like to not have a drink of water. Inform the students that they may not drink water the entire morning or afternoon preceding the conclusion of the activity.
- 2) Place the glass of water on a desk in the front of the classroom to visually remind students of water.
- 3) About one half-hour before lunch or the conclusion of the school day, provide students with the following questions to answer individually or as a group.

Discussion

- 1) An average glass can hold 12 ounces of a liquid such as water. An average drip from a sink can waste 5 gallons of water per day or 240 ounces per day. How many glasses of water could be saved per day by fixing the leak? (Answer: 20)
- 2) An average bathtub uses 36 gallons of water while the average short shower uses only 25 gallons — a difference of 11 gallons or 1408 ounces. Approximately how many glasses of water could be saved if a person took a short shower instead of a bath? (Answer: 117.3)
- 3) Do you think that some glasses of water could be saved if people filled dishwashers or washing machines with partial rather than full loads? (No. Most dishwashers and washers use the same amount of water, no matter if there is a full or partial load; in some models the cycle can be changed.)

- 4) What other conservation measures can you think of that would save glasses of water? (Answers will vary.)
- 5) How thirsty do you feel after not receiving water the entire morning or afternoon? (Answers will vary.)
- 6) How do you think you would feel if you could only have several ounces of water each day? (Very thirsty, sick, and eventually dead.)

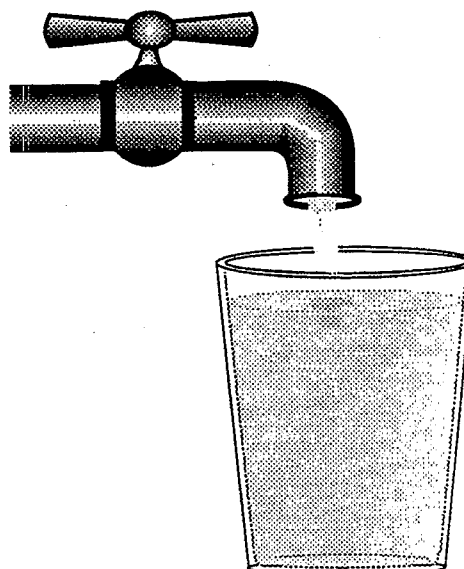
Suggested Activities

Many other activities can teach students about water conservation, including "water audits" of personal, family, and even school-wide water use. A variation of the "Water Use Analysis" project presented later in this pamphlet may be appropriate to demonstrate how people use water differently. A discussion of how various cultures (e.g., desert versus city dwellers) value water as well as spend time and effort obtaining it might also be useful.

Source

Activity adapted with permission from:

Water and Water Conservation Curriculum. (Aurora, CO: Aurora Utilities Department). p. 197.



middle

How Substances are Measured in Water

Background

We often find references to parts per million, parts per billion, and even parts per trillion in our everyday reading and news reports. What do they mean? Most of us have difficulty imagining large numbers of objects. How many stars can you see in the clear night sky far away from the smog and lights of the city? What does it mean when we read that an insecticide has been found in our groundwater at a concentration of 5 parts per billion? Developing an understanding of extremely large and extremely small numbers is very difficult.

Objective

To visualize the concept of extremely small numbers.

Material

1 bottle of food coloring

1 medicine dropper

1 white egg carton (6 or 12 eggs) or six small clear plastic cups

2 other containers to hold food coloring and water

Procedure

- 1) Prior to conducting the activity, ask students to consider the following:
 - a) What is the largest number of things you can clearly visualize in your mind? [Most of us can handle 5, 10, perhaps even 20 if we use all of our fingers and toes.]
 - b) Can you visualize a group of 100 people? [Many people think they can by describing a party or community meeting. If you try to visualize a group of 80 or 120 differently from the 100, it soon becomes apparent that our visualization is not that clear. The Rose Bowl full of people represents about 100,000. Trying to pick out just 1 individual in that crowd would be finding 1 in 100,000.]
 - c) Food coloring from the store is usually a 10% solution. What does 10% mean? [It means 10

parts (by weight) of solid food coloring dye is dissolved in 100 parts (by weight) of solution. For example, 10 grams of dye dissolved in 90 grams of water make a total of 100 grams of 10% solution.]

- 2) Put some food coloring (5 or 6 drops from the bottle) into one small container and some tap water into the other.
- 3) Use the medicine dropper to place one drop of 10 percent food coloring (as it comes from the store) into the first container. [Since 10% means 10 parts of food coloring per 100 parts of solution, it is the same as 1 part food coloring in 10 parts of solution.]
- 4) Use the medicine dropper to add 9 drops of water to the first container. Stir well. What is the concentration of the food coloring? [You have 1 drop of the original food coloring in 10 drops of the new solution. Thus the concentration of the new solution is 1/10 of the original. The original was 1 part in 10, so the concentration of the food coloring is now 1/10 of 1 part in 10. This is 1 part in 10×10 , or 1 part of food coloring in 100 parts of solution.]
- 5) Use the medicine dropper to transfer 1 drop of solution to the next container. Add 9 drops of water. Mix. You have again changed the concentration by a factor of one-tenth. What is the food coloring concentration in this container? [1/10 of 1 part in 100 is 1 part in 10×100 , or 1 part in 1000 parts of solution.]
- 6) Transfer one drop of the 1 part in 1000 parts of solution into the next container. Add 9 drops of water. Mix. What is the concentration? [1 part in 10,000 parts of solution.]
- 7) Continue to dilute 1 drop of each solution by adding water as before to obtain 1 part in 100,000 and then 1 part in 1,000,000. Your final solution is one part per million.

Discussion

- 1) In which cavity do you first observe no visual evidence that food coloring is present? [This generally occurs in the final container, which is 1 ppm of food coloring.]
- 2) Since you cannot see any color present, how do you know there is indeed food coloring present?
- 3) Can you think of an experiment that you could do to prove there is food coloring present in each cup? Do it.

- 4) Which is more concentrated, one part per million or 200 parts per billion? [A billion is a thousand million. Therefore, 1 ppm is 1000 ppb. 1 ppm is more concentrated than 200 ppb.]

Sources

Activity adapted with permission from:

Chemicals in Society Participant's Guide. (Berkeley, CA: Chemical Education for Public Understanding Program, University of California at Berkeley, 1989). pp. 5-6.

Conserving the Nation's Water Resources

Background

People require an average of 2 L of water per day to sustain life. However, the average American uses about 100 times more water than this every day at home. An average family of four in the United States might use about 900 L of water per day for the purposes identified in the table below.

Approximate daily water use by a family of four in the U.S.

Use	Liters per Day
Drinking and cooking	30
Dishwasher (3 loads per day)	57
Toilet (16 flushes per day)	363
Bathing (4 baths or showers per day)	303
Laundry clothes	130
Watering houseplants	4
Rinsing garbage into disposal unit	13
Total daily use:	900 L

(A reminder: 1 gallon = 3.8 L; 26.3 gallons = 100 L. The total daily water use of 900 L is equal to about 237 gallons.)

Source: *Earth: The Water Planet*

Objective

To provide a real-life model of how much water a family typically uses on a daily basis; to allow participants to experience firsthand how much effort is required to transport water; and to illustrate that when people desire, they can sharply reduce their water usage.

Materials

A schoolyard or large room with a water source
Two 122 L (32 gallon) trash cans
Empty milk jugs and/or buckets (as many as possible)
100 L of water
A watch or clock with a second hand
A meter stick (optional)

The story begins:

One cold January, the Smith family rent a house in the mountains for a ski vacation. The house, though old, has all the comforts of home — three bathrooms, a complete laundry room, dishwasher, and garbage disposal, plus a newly installed solar hot water heating system. Unfortunately, the weather gets so cold one night that a water main in town breaks, and the Smiths find out that the house will have no water service from the local utility for the entire week. What should they do — go back home or try to find another water supply?

Mr. Smith learns from a neighbor that there is an unfrozen spring 100 m from the house that could still be used for drinking water. Mrs. Smith, who is a mechanical engineer, discovers that if the municipal water line coming into the house were shut off, the water in the storage tank for the solar water heater could be routed directly into the plumbing system. The water system in the house will work as long as the storage tank is kept filled with water from the spring.

Mr. and Mrs. Smith discuss the situation with their two children Alice (14) and Sam (12). The family decides to form a "family bucket brigade" from the spring to the house, fill the storage tank each day, and continue their vacation. The storage tank can hold about 900 L of water.

Procedure

- 1) Place the two trash cans 100 m apart (measure with a meter stick or the distance is equal to approximately 150 paces for an average size adult).
- 2) Place 100 L of water in one of the trash cans. This can will represent the spring.
- 3) Select four students to represent the Smith family; equip each person with as many buckets and milk jugs as he/she can carry; and have students transfer the 100 L of water from the spring to the house (the house being represented by the second trash can located 100 m away).

middle

- 4) Have students record the time when the Smith family begins and finishes carrying the first 100 L of water. Students should then determine the total time that was required for the Smith family to transfer all of the water.
- 5) The Smiths may feel a little tired after transferring the 100 L of water. Thus far, they have only carried 11 percent of the water required to fill the tank. They still have 800 L to go. To save water (since this is role playing), have the Smiths bring the same 100 L back from the house to the spring rather than getting additional water out of the faucet being used.
- 6) The Smiths should continue carrying the water back and forth until the 100 L of water has changed cans a total of nine times, and the Smiths have carried the equivalent of 900 L of water 100 m to the house.
- 7) Have students record the time when the Smiths finish moving the entire 900 L of water from the spring to the house. Ask students the total amount of time (probably will be about 30 minutes) that was required to move the 900 L of water.

The story continues:

After carrying all of the water, the Smiths are too tired to ski very much. They come home early, have spaghetti for lunch, wash the dishes, and launder their bucket brigade clothes (which got muddy at the spring). After eating dinner, washing more dishes and clothes, watering the houseplants, and taking long, hot showers, they go to bed.

It is snowing too hard the next day to ski, so the Smiths stay in the house all day. When Mr. Smith tries to start the dishwasher after lunch, he discovers that the family is out of water! Sam and Alice groan and say that they would rather be grounded until they are 21 than carry 900 L of water to the house every day. They point out that they haven't even been in the house a full 24 hours since previously carrying the water.

Discussion

Have students identify and defend water conservation measures. What steps could the Smiths have taken to conserve water and save their ski vacation? (Some conservation measures include washing clothes less frequently, running the dishwasher once per day, fixing

any leaking plumbing fixtures, taking quick showers, not flushing toilets after every use, reducing the amount of water required for toilet flushing, etc.)

Source

Activity adapted with permission from:

Jack E. Gartrell, Jr., Jane Crowder, and Jeffrey C. Callister. *Earth: The Water Planet*. (Washington, DC: The National Science Teachers Association, 1989). pages 85-89.

How Water Is Cleaned

Background

Water in lakes, rivers, and swamps often contains impurities that make it look and smell bad. The water may also contain bacteria and other microbiological organisms that can cause disease. Consequently, water from surface sources must be "cleaned" before it can be consumed by people. Water treatment plants typically clean water by taking it through the following processes: 1) **aeration**; 2) **coagulation**; 3) **sedimentation**; 4) **filtration**; and 5) **disinfection**. Demonstration projects for the first four processes are included below.

Objective

To demonstrate the procedures that municipal water plants use to purify water for drinking.

Materials

5 L of "swamp water" (or add 2 1/2 cups of dirt or mud to 5 L of water)

One 2 L plastic soft drink bottle with its cap (or cork that fits tightly into the neck of the bottle)

Two 2 L plastic soft drink bottles — one bottle with the top removed and one bottle with the bottom removed

One 1.5 L (or larger) beaker or another soft drink bottle bottom

20 g of alum (potassium aluminum sulfate — approximately 2 tablespoons; available at a pharmacy)

Fine sand (about 800 ml in volume)

Coarse sand (about 800 ml in volume)

Small pebbles (about 400 ml in volume)

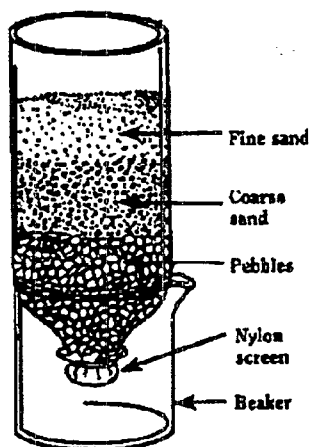
A large (500 ml or larger) beaker or jar

A small (approximately 5 cm x 5 cm) piece of flexible nylon screen

A tablespoon

A rubber band

A clock with a second hand or a stopwatch



Source: Earth: The Water Planet

Procedure

- 1) Pour about 1.5 L of "swamp water" into a 2 L bottle. Have students describe the appearance and smell of the water.
- 2) **Aeration** is the addition of air to water. It allows gases trapped in the water to escape and adds oxygen to the water. Place the cap on the bottle and shake the water vigorously for 30 seconds. Continue the aeration process by pouring the water into either one of the cut-off bottles, then pouring the water back and forth between the cut-off bottles 10 times. Ask students to describe any changes they observe. Pour the aerated water into a bottle with its top cut off.
- 3) **Coagulation** is the process by which dirt and other suspended solid particles are chemically "stuck together" into floc so that they can be removed from water. With the tablespoon, add 20 g of alum crystals to the swamp water. Slowly stir the mixture for 5 minutes.
- 4) **Sedimentation** is the process that occurs when gravity pulls the particles of floc (clumps of alum and sediment) to the bottom of the cylinder. Allow the water to stand undisturbed in the cylinder. Ask

students to observe the water at 5 minute intervals for a total of 20 minutes and write their observations with respect to changes in the water's appearance.

- 5) Construct a filter from the bottle with its bottom cut off as follows (see illustration at left):
 - a) Attach the nylon screen to the outside neck of the bottle with a rubber band. Turn the bottle upside down and pour a layer of pebbles into the bottle — the screen will prevent the pebbles from falling out of the neck of the bottle.
 - b) Pour the coarse sand on top of the pebbles.
 - c) Pour the fine sand on top of the coarse sand.
 - d) Clean the filter by slowly and carefully pouring through 5 L (or more) of clean tap water. Try not to disturb the top layer of sand as you pour the water.
- 6) **Filtration** through a sand and pebble filter removes most of the impurities remaining in water after coagulation and sedimentation have taken place. After a large amount of sediment has settled on the bottom of the bottle of swamp water, carefully — without disturbing the sediment — pour the top two-thirds of the swamp water through the filter. Collect the filtered water in the beaker. Pour the remaining (one-third bottle) of swamp water into the collection bucket. Compare the treated and the untreated water. Ask students whether treatment has changed the appearance and smell of the water. [Inform students that a water treatment plant would as a final step disinfect the water (e.g., would add a disinfectant such as chlorine gas) to kill any remaining disease-causing organisms prior to distributing the water to homes. Therefore, the demonstration water is not safe to drink.]

Discussion

- 1) What was the appearance of the swamp water? (Answers will vary, depending on the water source used. Water from some sources may be smelly and/or muddy.)
- 2) Does aeration change the appearance or smell of water? (If the original water sample was smelly, the water should have less odor after aeration. Pouring the water back and forth allows some of the foul-smelling gases trapped to escape to the air of the room. Students may have observed small bubbles

middle

suspended in the water and attached to the sides of the cylinder.)

- 3) How did the sedimentation process effect the water's appearance? Did the appearance of the water vary at each 5 minute interval? (The rate of sedimentation depends on the water being used and the size of alum crystals added. Large particles will settle almost as soon as stirring stops. Even if the water contains very fine clay particles, visible clumps of floc should form and begin to settle out by the end of the 20-minute observation period.)
- 4) How does the treated water (following filtration) differ from the untreated swamp water? (After filtration, the treated swamp water should look much clearer than the untreated water. It probably will not be as clear as tap water, but the decrease in the amount of material suspended in the water should be quite obvious. The treated sample should have very little odor when compared to the starting supply of swamp water.)

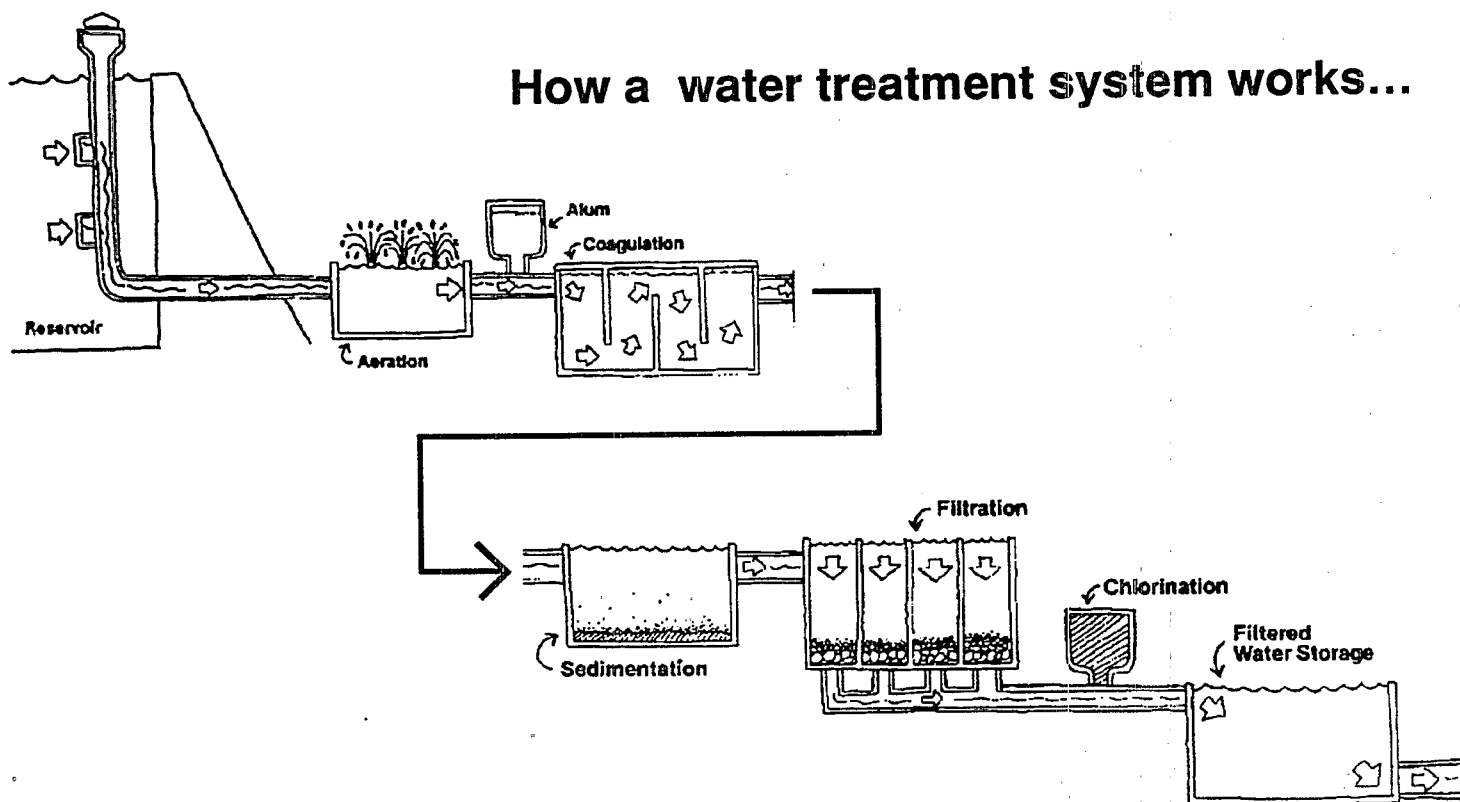
Suggested Activities

- A field trip to a local water treatment plant.
- Have the State or a certified testing laboratory conduct analyses of the students' treated and untreated water for various contaminants.

Source

Activity adapted with permission from:

Jack E. Gartrell, Jr., Jane Crowder, and Jeffrey C. Callister. *Earth: The Water Planet* (Washington, DC: The National Science Teachers Association, 1989). pp. 97-101.



Concentrations of Chemical Pollutants in Water

Background

Concentrations of chemical pollutants in water are frequently expressed in units of "parts per million" (ppm) or "parts per billion" (ppb). For example, chemical fertilizers contain nitrates, a chemical that can be dangerous to pregnant women even in quantities as small as 10 parts per million. Trichloroethylene (TCE), a common industrial solvent, is more dangerous than nitrates and when present in drinking water in quantities as small as 5 parts per million can cause a higher than normal incidence of cancer among people who drink the water regularly.

Objective

To demonstrate the concept of ppm and ppb as these units are used to explain chemical contaminant concentrations in water; to explain how chemicals may be present in very small amounts in water such that they cannot often be detected by sight, taste, or smell; though, still possibly posing as a threat to human health.

Materials

Solid coffee stirrers or tooth picks

Clean water for rinsing the dropper

Medicine dropper

Red food coloring (for "contamination")

Set of 9 clear containers

Clean water for diluting

White paper

Procedure

- 1) Line up the containers side-by-side and place a piece of white paper under each one. From left to right, number the containers 1 to 9.
- 2) Place 10 drops of food coloring into container #1 (food dye is already diluted 1:10).

- 3) Place one drop of food coloring into container #2.
- 4) Add 9 drops of clean water to container #2 and stir the solution. Rinse the dropper.
- 5) Use the medicine dropper to transfer 1 drop of the solution from container #2 into container #3. Add 9 drops of clean water to container #3 and stir the solution. Rinse the dropper.
- 6) Transfer 1 drop of the solution from container #3 to container #4. Add 9 drops of clean water to container #4 and stir the solution. Rinse the dropper.
- 7) Continue the same process until all 9 containers contain successively more dilute solutions.
- 8) Complete the discussion questions below.

Discussion

- 1) The food coloring in container #1 is a food coloring solution which is one part colorant per 10 parts liquid. What is the concentration for each of the successive dilutions? (Have students use the table below; each dilution decreases by a factor of 10—1/10, 1/100, 1/1000, etc.)
- 2) What is the concentration of the solution when the diluted solution first appeared colorless? (Usually occurs in container #6, 1/1,000,000 or 1 ppm.)
- 3) Do you think there is any of the colored solution present in the diluted solution even though it is colorless? Explain. (Yes. The solution is still present but has been broken down into such small particles that it cannot be seen.)
- 4) What would remain in the containers if all the water were removed? (Residue from the food coloring.)

Suggested Activities

- 1) Allow the water in the containers to evaporate and have students record their observations on what remains in the containers.
- 2) Discuss chemical contamination of drinking water. Use the list of maximum contaminant levels (MCLs) on the following page for some toxic or carcinogenic chemicals in drinking water (as regulated by

Container No.	1	2	3	4	5	6	7	8	9
Concentration	1/10	1/	1/	1/	1/	1/	1/	1/	1/

Source: Water Wisdom

secondary

the U.S. Environmental Protection Agency). These MCLs represent the maximum amount of a chemical that can occur in drinking water without the water being dangerous to human health. [Note: Some of the MCLs listed are subject to revision by EPA shortly.]

Substance	Concentration (ppb)	Substance	Concentration (ppb)
Arsenic	50	Nitrate	10,000
Barium	1,000	Selenium	10
Cadmium	10	Endrin	0.2
Mercury	2	2,4-D (herbicide)	100

Note: The above substances do not represent a complete list of regulated drinking water contaminants.

- 3) Explain the relationship between ppm and ppb and the conversion of these units to milligrams and micrograms per liter. For example: 1 ppm = 1000 ppb; 1 ppm = 1 mg/l; and 1 ppb = 1 ug/l.
- 4) Relate the previous conversions to the drinking water regulations. [MCLs are established in milligrams per liter (mg/l)]. Convert the numbers in the above chart from ppb to mg/l.

Source

Activity adapted with permission from:

Water Wisdom. (Boston, MA: Massachusetts Water Resources Authority, 1989). Exercise #16.

Contamination of an Aquifer

Background

Many communities obtain their drinking water from underground sources called **aquifers**. Water suppliers or utility officials drill wells through soil and rock into aquifers for the groundwater contained therein. Unfortunately, the groundwater can become contaminated by harmful chemicals that percolate down through soil and rock into the aquifer—and eventually into the well. Groundwater contamination by chemicals is caused mainly by industrial runoff and/or improper management of chemicals, including improper disposal of household chemicals such as lawn care products and cleaners. Such contamination can pose a significant threat to human health. The measures that must be taken by utilities to either protect or clean up

contaminated aquifers are quite costly.

Objective

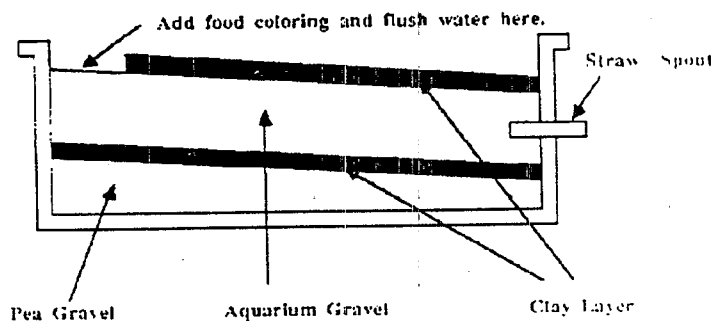
To illustrate how water flows through an aquifer, how groundwater can become contaminated, and how difficult it is to clean up contamination.

Materials

6"x8" disposable aluminum cake pans or plastic boxes
 2 lbs. non-water soluble plasticine modeling clay or floral clay
 3-4 lbs. white aquarium gravel
 Pea gravel
 Small drinking straw
 Food coloring
 6 oz. paper cups (no larger)
 Water

Procedure

- 1) Set up a model aquifer as shown in the diagram below. If a disposable aluminum baking pan is used, make a small hole in one end and insert a section of a drinking straw to serve as the drain spout. Seal the hole around the straw with glue or clay. In addition, seal the clay layers of the model against the side of the container.
- 2) Place 10 drops of food coloring on the surface of the model near the highest end. This dye represents chemicals or other pollutants that have been spilled on the ground.
- 3) Slowly pour one 6-ounce cup of tap water on the aquarium gravel areas as shown in the diagram. Collect the water as it runs out of the straw. Repeat this process starting with 6 ounces of tap water and continue the flushing process until all the food coloring is washed out and the discharge water is



Source: *Water Wisdom*

clear. (Collecting the water in white paper cups or in test tubes held up against a white background will enable students to detect faint coloration.)

- 4) Record the number of flushings required until an output with no visible color is reached (may require up to ten flushes). [Note: 6 ounces of water in this model equals about 1 inch of rain.]

Discussion

Before the Activity

- 1) Where does the water go that falls on the surface of an aquifer? How about any chemicals or other pollutants that fall on the ground? (Some chemicals/pollutants are washed away by rain, some become attached to rocks and soil, and some end up in the groundwater.)
- 2) What things might influence the time needed to flush an aquifer clean? (Depth and volume of the water table, type of underlying rock and soil, nature and concentration of the pollutant.)

After the Activity

- 1) After flushing, is the water in the model aquifer completely free of food coloring? (Probably not; trace amounts may remain.)
- 2) Estimate how much contamination remains in the model aquifer. (Refer to previous exercise.)
- 3) What keeps the chemical contamination in the demonstration from reaching the lower levels of the model aquifer? (The clay layer.)
- 4) What are some of the problems that might result from a major chemical spill near a watershed area? (Answers will vary.)
- 5) What steps could be taken to avoid damage to an aquifer? (Answers will vary.)

Suggested Activities

- 1) Discuss the need for proper disposal of hazardous industrial wastes and harmful household chemicals, including used motor oil.
- 2) Simulate nitrate pollution due to fertilizer runoff. Pollute the aquifer with a small amount of soluble nitrate and perform a standard nitrate test after each successive flushing (be sure to wear safety glasses).

Source

Activity adapted with permission from:

Water Wisdom. (Boston, MA: Massachusetts Water Resources Authority, 1989). Exercise #11.

Water Use Analysis

Background

Although household and other municipal water use accounts for only about 9 percent of total water use in the United States, delivering adequate quantities of water of sufficient quality for this purpose is becoming increasingly expensive for individuals and communities. It would, therefore, be useful for individuals and communities to employ conservation measures when using water.

Objective

To demonstrate the quantities of water that an average family uses on a daily basis.

Procedure

- 1) Ask students to keep a diary of water use in their homes for three days. Students should make a chart similar to the one listed on the following page, adding any appropriate activities that are not listed.
- 2) Ask students to review the table of average water volumes required for typical activities and then answer the following questions using the data from their three-day water use diary.
 - a) Estimate the total amount of water your family used in the three days. Give your answer in liters.
 - b) On average, how much water did each family member use during the three days? Give your answer in liters per person per three days.
 - c) On average, how much water was used per family member each day? Give your answer in liters per person per day.
 - d) Compare the daily volume of water used per person in your household (Answer c) to the average daily water volume used per person in the United States (325 L per person per day). What reasons can you offer to explain any differences?

secondary

Discussion

Ask students to identify ways in which their families could reduce their water consumption.

Source

Activity adapted with permission from:
American Chemical Society. *Chemistry in the Community*. (Dubuque, IA: Kendall/Hunt Publishing Co., 1988). pp. 11, 16-17.

Average water volumes required for typical activities

Use	Volume of Water (in liters and gallons)
Tub bath	130 L (35 gal)
Shower (per min)	19 L (5 gal)
Washing machine	
Low setting	72 L (19 gal)
High setting	170 L (45 gal)
Dish washing	
By hand	40 L (10 gal)
By machine	46 L (12 gal)
Toilet flushing	11 L (3 gal)

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Data Table	Days		
	1	2	3
Number of persons in family			
Number of baths			
Number of showers			
Length of each in minutes			
Number of washing machine loads			
Low setting			
High setting			
Dish washing			
Number of times by hand			
Number of times by dishwasher			
Number of toilet flushes			
Other uses and number of each:			
Cooking			
Drinking			
Making juice and coffee			

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notes

references

The organizations below have developed or are in the process of developing science projects related to drinking water for K-12 students. This list is not intended to be inclusive.

American Chemical Society (ACS), 1155 16th St., NW, Washington, DC 20036, (202) 872-4600 [*Chemistry in the Community*—Secondary 9-12].

American Water Works Association (AWWA), 6666 West Quincy Ave., Denver, CO 80235, (303) 794-7711 [Primary K-4; Middle/Junior 5-9].

Chemical Education for Public Understanding Program (CEPUP), Lawrence Hall of Science, University of California, Berkeley, CA 94720, (415) 642-3718 [Middle/Junior 5-8].

City of Aurora, Utilities Department, 1470 South Havana St., Aurora, CO 80012, (303) 695-7381 [Middle/Junior 5-8].

City of Seattle, 710 2nd Ave., Dexter-Horton Building, Seattle, WA 98104, (206) 684-5883 [Middle/Junior 5-8].

East Bay Municipal Utility District (EBMUD), P.O. Box 24055, Oakland, CA 94623, (415) 835-3000 [Primary K-4; Middle/Junior 5-8].

Massachusetts Water Resources Authority, Charlestown Navy Yard, 100 First Ave., Boston, MA 02129, (617) 242-6000 [Upper Primary 3-4; Middle/Junior 7-8; Secondary 9-12].

National Science Teachers Association (NSTA), 1742 Connecticut Ave., NW, Washington, DC 20009, (202) 328-5800 [Middle/Junior 5-8].

National Wildlife Federation (NWF), 1400 16th St., NW, Washington, DC 20036, (202) 797-6800 [Primary K-4; other citizen oriented material].

South Central Connecticut Regional Water Authority, 90 Sargent Dr., New Haven, CT 06511, (203) 624-6671 [Primary and Middle K-6].

suppliers

The following are some firms that provide general supplies and equipment for all areas of science teaching and also specific items for chemistry teaching.

Addison-Wesley Publishing Co., 2725 Sand Hill Rd., Menlo Park, CA 94025, [800-447-2226].

Aldrich Chemical Co., P.O. Box 355, Milwaukee, WI 53201, (414) 273-3850, [800-558-9160].

Carolina Biological Supply Co., 2700 York Rd., Burlington, NC 27215, (919) 584-0381 [800-621-4769].

Central Scientific Co., 11222 Melrose Ave., Franklin Park, IL 60131-1364, (312) 451-0150.

Connecticut Valley Biological Supply Co., Inc., 82 Valley Rd., Southamptn, MA 01073, (413) 527-4030 [800-628-7748].

Edmund Scientific Co., 101 East Gloucester Pike, Barrington, NJ 08007, (609) 573-6250 [800-222-0224].

Fisher Scientific Co., Educational Materials Division, 4901 West LeMoyné St., Chicago, IL 60651, (312) 378-7770 [800-621-4769].

Flinn Scientific Inc., P.O. Box 231, 917 West Wilson St., Batavia, IL 60510, (312) 879-6900. [The Flinn Chemical Catalog also serves as a reference manual on chemical safety, storage, and disposal.]

Frey Scientific Co., 905 Hickory Lane, Mansfield, OH 44905, [800-225-FREY].

Hach Chemical Co., Box 907, Ames, IA 50010. [Test kits for environmental studies.]

Lab-Aids, Inc., 249 Trade Zone Dr., Ronkonkoma, NY 11779, (516) 737-1133.

Lab Safety Supply, 3430 Palmer Dr., P.O. Box 1368, Janesville, WI 53547-1368, (608) 754-2345. [Specialize in safety equipment and supplies.]

LaMotte Chemical Products, Box 329, Chestertown, MD 21620, (301) 778-3100. [Test kits for environmental studies.]

Nalgene Labware Division, P.O. Box 367, Rochester, NY 14602. [Specialize in transparent and translucent plastic laboratory equipment.]

NASCO, 901 Janesville Ave., Ft. Atkinson, WI 53538, (414) 563-2446 [800-558-9595].

Ohaus Scale Corp., 29 Hanover Rd., Florham Park, NJ 07932, (201) 377-9000 [800-672-7722].

Sargent-Welch Scientific Co., 7300 North Linder, Skokie, IL 60077, (312) 677-0600.

Science Kit and Boreal Laboratories, Inc., 777 East Park Dr., Tonawanda, NY 14150-6782, (716) 874-6020 [800-828-7777].

Wards Natural Science Establishment, Inc., 5100 West Henrietta Rd., P.O. Box 92912, Rochester, NY 14692, (716) 359-2502.

[The majority of suppliers listed above appeared in *Chemistry in the Community*, American Chemical Society. (Dubuque, IA: Kendall/Hunt Publishing Co., 1988).]



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